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Geophysical Research Abstracts
Vol. 18, EGU2016-14847, 2016
EGU General Assembly 2016

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One of the key challenges associated with the large-scale penetration of solar power is the inherent spatio-temporal variability of the solar radiation impinging on the surface. Particular methods are currently employed to measure, estimate or forecast the extent and availability of the solar resource depending on the effective spatial and temporal scales of interest, such as numerical weather prediction models, satellite-based estimates, sky-imagers or in-situ ground measurements.

Here we present a method for characterizing the intrinsic time-scales of the solar resource variability. The study deals with decennial time-series of daily values of the surface solar irradiance (SSI) issued from high-quality BSRN ground measurement stations. Geophysical signals, such as the SSI time-series under scrutiny, are often the result of non-linear interactions of physical processes that are also often under natural or anthropogenic non-stationary forcings. Therefore, an adaptive data analysis technique is employed that makes no beforehand assumptions about the data: neither linearity, nor stationarity of the signal is assumed. The method, called the Hilbert-Huang transform, first extracts all the embedded oscillations that have a similar time-scale, to which it then applies Hilbert spectral analysis. A time-frequency-energy representation of the signal is thus constructed, which reveals the time-varying character of the intrinsic temporal scales of variability (frequency modulation), along with any fluctuations in the intensity of the signal at the corresponding scale (amplitude modulation).

In order to test whether the features extracted from the data are the expression of deterministic physical processes, as opposed to being stochastic realizations of various background processes (i.e. noise), a novel, adaptive null-hypothesis based on the statistical properties of noise is employed. It is shown that the data, irrespective of the geographical conditions, shares common time-scales of variability, along with a plateau of noise-like features, whose amplitude is found to be modulated by variations in the intensity of the seasonal cycle.

In characterizing the local time-scales of variability of the solar resource, the main contributions of the study are the introduction of the amplitude modulation-frequency modulation signal model and the use of an adaptive null-hypothesis covering a general class of background noise models. Thus, the study has conceivable ramifications in the long-term modeling and the forecast of the solar resource, by providing a methodology for differentiating the deterministic components of the data from the stochastic expression of various background processes, at different time-scales.